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ABSTRACT

This report describes a new approach to teaching science, math, and technology to students, especially girls, with disabilities, who frequently do not have access to appropriate instruction in these critical areas for future academic success. Many specific suggestions, along with a sample lesson that can be used immediately, are presented as part of a total instructional model that stresses best practices in science and math education, gender equity, cultural relevance, and inclusionary education. Other related resources, such as a case study and related Individualized Education Program (IEP) goals and objectives are also provided for both regular and special educators as illustrations of how to teach science, math, and technology effectively to students with disabilities in elementary and middle school classrooms. The report begins by describing findings from two National Science Foundation Projects, "Daughters with Disabilities," and "Sisters in Science," designed to encourage more girls with disabilities to prepare for careers in science, math, and technology. The professional literature is reviewed and then a sample lesson is provided. Appendices include lesson worksheets, suggestions, and examples of Individualized Education Program goals and objectives. (Contains 27 references.) (CR)

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Daughters with Disabilities: Reframing Science, Math, and Technology for Girls with Disabilities

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Abstract

The focus of this article is to describe a new approach to teach science, math, and technology to students, especially girls with disabilities, who frequently do not have access to appropriate instruction in these critical areas for future academic success. Many specific suggestions, along with a sample lesson that can be used immediately, are presented as part of a total instructional model that stresses best practices in science and math education, gender equity, cultural relevance, and inclusionary education. Other related resources, such as a case study and related Individual Educational Plan (IEP) goals and objectives, are also provided for both regular and special educators as illustrations of how to effectively teach science, math, and technology to students with disabilities in elementary and middle school classrooms.

"I grew up hating science. I was never good at it through school and out of that developed a fear of teaching it. Even when I took my science method [class], I was still horrified about putting together a comprehensive science lesson plan. I knew that I wasn't strong in science and I was constantly worried that the students would ask me a question that I couldn't answer. . . . I always thought that science was extremely dry and boring. All of the experiments that I performed in school were confusing, focusing mostly on cause and effect. I usually spaced-out during the experiments and relied mostly on my science lab partner to get me through." (Price & Hammrich, 2001).

Do these comments by a Special Educator sound familar to you? Whether you are a seasoned professional or a novice teacher, do you still hesitate to teach science or math or technology with as much ease as you would teach reading or writing to your students? Do you avoid doing science experiments in your classroom? Are your lesson plans full of rote learning to teach computation skills? Do you focus on only basic computer games for instructional technology? If so, you are not alone. You share the experiences of many professionals in both regular and special education. The professional literature in these areas supports a number of important trends that clearly will have a negative impact on the science, math, and technology education for students with disabilities (Balzer & Roberts, 1993; Burgstahler, 1996; Rivera, 1997; Shewey, 1997). But, this literature and our own experiences in the classroom point to a deeper, more disturbing trend--while education for students with disabilities is often lacking in these areas--girls in these classrooms are at special risk to receive an appropriate education in science, math, and technology. In fact, we have found that girls with disabilities are in triple jeopardy. These students, who are educated in urban school districts, often fail to gain the knowledge in science, engineering, mathematics, and technology (SEMT) that clearly is so critical to their future success as adults, as women, and as active citizens in their communities (Burgstahler, 1994; Price, Hammrich, & Nourse, 2000; Skolnick, Langbort, & Day, 1982; Wilson & Milson, 1993).

As a result, the focus of this article is two-fold. First, we will briefly discuss applicable trends in the professional literature concerning how science, math, and technology are currently taught to students, especially girls with disabilities, in special education settings. Secondly, we will describe a sample lesson, along with specific suggestions that have been useful to make this material effective in inclusive settings, that we have found to be helpful to spark the interest and achievement of girls with disabilities in a variety of elementary classrooms in an inner-city school district. In addition, to make this material easier for special educators to use immediately in their own settings, we have included as many hints, ideas, and resources as possible.

We have found that such valuable information is often a priceless key to unlock the puzzle of appropriate science, math, and technology instruction for both girls with and without disabilities. This expectation is based on our past and current work with two projects funded by the National Science Foundation--Sisters In Science and Daughters with Disabilities.

Two National Science Foundation Projects

The overall purpose of Daughters with Disabilities was to encourage more girls with disabilities from six, inner-city schools in North Philadelphia to prepare for the careers in Science, Engineering, Math, and Technology (SEMT). This broadly-based goal was implemented in a variety of ways, including: 1) Increasing the interest and achievement in Science, Math, and Technology of girls in special education classes at the five participating schools; 2) Enhancing existing Science, Math, and Technology curricula for girls with disabilities in urban settings; 3) Introducing and teaching the concept of "pre-transition" knowledge (i.e., future postsecondary education awareness and career exploration through various activities, experiences, mentors strategies, etc.) in the SEMT areas; and 4) Creating a network of support and training for pre-service and in-service special and regular education teachers, families, and community members in the areas of Science, Math, and Technology that stressed gender-sensitive curricula, instructional modifications, and successful inclusive education.

The overall goal of Daughters with Disabilities was supported and enhanced by a variety of related activities (e.g., summer programs, summer teacher training, the Saturday Academy, professional development, undergraduate teacher training, outreach to schools, materials dissemination, one-to-one consultation to participating teachers and schools). It should also be noted that Daughters with Disabilities was originally based on a previously funded NSF project--Sisters in Science (Hammrich, Richardson, & Livingston, 2000; Price, Hammrich, & Nourse, 2000).

Sisters in Science (SIS) was a four year, multi-generational project funded by the National Science Foundation that addressed the relationship between gender equity and effective instruction in the areas of science, math, and engineering for students in elementary classrooms. The model was based on the extensive efforts of wide variety of female educators, staff, volunteers, and retirees to provide a range of activities (e.g., on-site classroom activities, an after school program, field trips and a two week Summer Institute on the Temple University campus) to teach SEMT knowledge and skills to 4th and 5th grade girls from 6 target elementary schools in the Philadelphia Public School System. During its existence, SIS involved over 560 girls and 160 pre-service and in-service elementary science and math teachers (Hammrich, 1997; Hammrich, et al, ß2000).

Findings from the 1997-1998 intervention are representative of the long-term impact that SIS made on both the girls and the professionals who worked with them. For example, staff found that there were significant differences between girls' and boys' pre- and post-mean scores in terms of attitude toward: girls in science, science involvement, and teacher attitude. Also, an analysis of variance was conducted on this data to note any changes in the pre-and post-scores for both boys and girls in the target 4th and 5th grade classrooms. The focus of this analysis was important science and math-related skills that are typically taught in the 4th grade (e.g., observation, recognition of variables in experiments, utilization of bar graphs, interpretation of graph results, classification, measurement with non-standard units, computation of averages, symmetry, and estimation of lengths). Using a science process skill assessment, some statistical significant changes were found for the females who participated in SIS activities. Of the previous skills, a significant change in female skill development was found pre- to post-measurement in terms of: observation, variable recognition, use and interpretation of bar graphs, classification, average computation, and length estimation.

Other important findings were revealed when data from the Stanford Nine Science and Mathematics scores were examined for these same girls who participated in SIS. In general, all six schools who participated in SIS reported and increase in their SAT 9 science and math scores throughout the years that SIS staff worked with their teachers and girls. While no formal statistical analysis was conducted on this data, growth scores reported from the 6 target schools ranged from 1.2 to 14.9, with a mean gain score of 7.9. Of equal importance, when compared with all of the schools in the

Philadelphia system, the 6 SIS target schools reported SAT 9 gain scores approximately 50% higher than non-SIS schools in the areas of math and science (Hammrich, et al, 2000).

What the Professional Literature Tells Us

As previously described, both Sisters In Science and Daughters with Disabilities were created to specifically address the concerns that individuals with disabilities, especially girls, were widely under-served and under-educated in the areas of science, math, engineering, and technology (Baker & Leary, 1995; Cawley, Kahn, and Tedesco, 1989; Donahue & Zigmond, 1986; Mastorpieri & Scruggs, 1991; NSF, 1996; Shewey, 1997; Stefanich & Dodd, 1994). This disturbing trend has its roots in a simple conclusion: Today the vast majority of the 5.3 American children or youth in special education programs are receiving inadequate or no education in the areas of science, engineering, math, and technology. A logical outcome of such poor SEMT educational experiences is the negative way that students with disabilities often perceive science and math. For instance, either they have no further interest in these areas or they are denied the opportunities to pursue further education because of their limited or non-existent knowledge base (Kaye, 1997; U. S. Department of Education, 1991; Stefanich; 1994).

An even more serious consequence is girls with disabilities do not consider higher education as an option. For instance, the U. S. Department of Education (1991) states that in 1992-93 only 6.3 per cent of undergraduates and 4.0 per cent of graduate students identified themselves as having disabilities. Such limited educational possibilities, in turn, restrict their lives as adults even more, as they cannot become practicing scientists, engineers, or math teachers. We also believe that this negative trend reflects a significant gender bias.

As Shewey (1997) explained,

> Although women, minorities, and persons with disabilities have made great progress integrating the science world, a disparity still exists in their representation in the science community. In every ethnic group, women still comprise a lower percentage of science and engineering students and professionals than men. These gaps grow larger with age and prominent career positions. . . Once they reach college, women are 10% less likely to choose a science or engineering major and much less likely to obtain a Ph.D. Women [now] comprise 30% of science and engineering Ph.D. candidates, which is an increase of 5% since 1983. (p.1)

We have found, as the professional literature clearly supports, that these disturbing trends often have their roots in elementary and middle school classrooms. For instance, many schools--especially those in the inner-city--often do not have the resources to provide an adequate special education programs. As George (1996) explained, "The provision of appropriate [special education] services rests in part on the districts ability to obtain an adequate supply of qualified personnel, to select appropriate curriculum and instructional methods, and to maintain active parent involvement" (p. 4). These concerns are further complicated by inner city schools that traditionally are burdened by such negative factors as: lack of funds, over-crowded classrooms, out-dated or non-existent laboratory equipment, few technology resources, and over-worked, ill-prepared teachers in the SEMT area (George, 1996; Rivera, 1997; Mastropieri, Scruggs, & Shiah, 1991, Mastropieri & Scruggs, 1992).

In addition, disability continues to play an important role in how both boys and girls with disabilities are educated in the areas of science, math and technology. For instance, both the professional literature and our own recent experiences underscore the concern students in special education classes rarely receive appropriate education in these critical areas to address their special needs (Baker & Zigmond, 1997; Rivera, 1997; Mastropieri, Scruggs, & Shiah, 1991, Mastropieri & Scruggs, 1992; Norman, & Caseau,1994;Ysseldyke, Thurlow, Wortruba, & Nanaia, 1990). In fact, basic remediation is often the extent of the math curricula for students with disabilities in most elementary and middle school classes. Also, due to the strong, curricular emphasis on beginning literacy and life skill development in special education resource rooms, science is usually completely neglected altogether (Rivera, 1997; Mastropieri, Scruggs, & Shiah, 1991, Mastropieri & Scruggs, 1992).

This critical short-fall is often complicated by the fact that most special educators are not prepared or poorly trained to teach science, math or technology to their students

(Baker & Zigmond, 1997; Balzer & Roberts, 1993; Stefanich; 1994; Ysseldyke, Thurlow, Wortruba, & Nanaia, 1990). As one of the participating teachers from Daughters with Disabilities told us, "We only got math methods in our undergraduate [training].....Our classes were too generalized for this stuff....." Another teacher agreed when she said, "It really depended on your undergraduate major whether you got any information about teaching science and technology." It was these concerns, along with the on-going need to teach science, math, and technological skills appropriately to students, especially girls, with disabilities that led us to design lesson plans similar to the one described in detail below.

A Sample Lesson Plan

As the professional literature clearly demonstrates, science, math and technology continue to be unexplored areas for both boys and girls with disabilities in American schools today. For instance, three important topics to understanding science as taught in elementary settings are the concepts of gravity, motion, and force. It is not unusual for both students with and without disabilities to hold misconceptions about the magnitude of the earth's gravitational force. If students do view weight as a force, they usually think it is air that exerts this force. Gravity describes the downward pull or force exerted on objects to ward the earth. Gravitational force pulls every particle of matter toward every other particle of matter in the universe. Motion, however, implies movement or the passage of an object from one place to another. Force, a related concept, is the cause or agent that puts an object that is a rest into motion. Force can also alter the motion of a moving object. Changes in speed or direction of an object are caused by force. Therefore, the larger the force, the greater the change in motion will be.

Given these concepts and basic definitions, the students will achieve the following goals as part of the this lesson plan: (1) Learn about objects falling at different rates of speed due to a variety of factors or variables; (2) Understand that gravity acts on objects differently because of the space that each occupies, the distance of the fall, and the weight of the object; (3) Discover that equal weights of matter may travel at the same speeds; and (4) Experiment with the idea that additional weight or force can accelerate one to equal the speed of two, when the surface area/friction are controlled (Hammrich, 2000).

They will also be able to define the terms: surface area, distance, gravity, force, and motion, while simultaneously determining the relationship between surface areas, distance of fall, and fall time. Other process skills involved in this and related lessons (see Sidebars) include: manipulating the variables of surface area with distance of a fall; predicting fall time for each object; collecting appropriate data for surface area, fall distance, and fall time; and plotting data on a line graph in terms of surface area versus fall time (Hammrich, 2000).

It is important to remember that all science lessons used with students with disabilities should also conform as much as possible to the Benchmarks originally developed by the American Association for the Advancement of Science, or AAAS (1993) for all American students in schools throughout the United States. Consequently, the following lesson plan on gravity is directly related to a AAAS Benchmark on Mathematics (i.e., Mathematical ideas can be represented concretely, graphically, and symbolically) and a AAAS Benchmark on Science (i.e., things on or near the earth are pulled toward it by the earth's gravity) (AAAS, 1993, pp. 27, 68).

You will need these common household or school materials for this lesson: paper towels, washers, paper clips, string, masking tape, pencils, scissors, stopwatches, measuring tapes, rulers, a hole punch, toy cars, charting paper, and an incline ramp. We suggest that you teach this lesson in groups of four students each, but you may also have the students work as partners. Before starting this lesson, your students should be able to: use time and linear measurement tools; be able to construct a square; be familiar with decimal numbers and their order; and plot (with help if necessary) ordered pairs of numbers.

Pre-assessment

To prepare both yourself and the students for a lesson on gravity, constancy, and change, you can use these activities first to evaluate their knowledge and skills in both science and math. First, present the students with a toy car on a flat surface. Ask the students this question: "What can you do to make the car move forward?" Keep soliciting responses from the students until they use the term "force". Second, place the car on an incline and ask the students the following questions: "What would happen to a car if it were placed on a hill?" and "What made the car move forward?" Elicit responses untile the students use the term "gravity". Third, Ask the students to redefine the terms that have already been used. Suggest to them they will be exploring the ideas of gravity, motion, and force further throughout the day's activities.

Introductory Activities on Surface Area, Weight, and Fall Distance

The next set of experiences in this lesson is designed to more formally introduce three scientific concepts that are crucial components of the broader themes of constancy and change. They are also central building blocks to understanding how gravity works in our environment everyday.

Concept One focuses on the idea of "surface area". You can address in this way. First, begin with two equal pieces of paper. One piece will get balled up while the other remains in its flat state. Each will be held at an equal height and dropped simultaneously. Then ask the students these questions, "Which one will hit the table first?" What makes the two pieces of paper fall at different rates of speed?" Second, you can take the ball of paper and the flat paper again. In the center of the flat paper, a string with a single washer will be added. Each of the pieces of paper (e.g., both balled and flat) will be dropped again simultaneously from equal heights. Then ask the students these questions, "Which one will hit the table? What makes the two pieces of paper fall at different rates of speed? How many washers will it take to make the tow objects hit the table at the same time? Why does adding weight make a difference?"

Concept Two looks at the idea of "weight". You can teach about this concept by taking two pieces of paper that are flat and adding one washer to Paper A and three washers to Paper B. Then ask the students these questions, "Which one will hit the table first? What makes the two pieces of paper fall at different rates of speed?"

Concept Three examines the concept of "fall distance". To learn more about this idea, you can take two pieces of paper with a single washer attached to each one from four feet and the other from eight feet. The experiment should be repeated with two pieces of paper, one with a single washer one with enough washers to make the two hit the surface at the same time. Then, ask: "Which piece of paper reaches the surface first? Why?" It is also useful to ask the students throughout all three exercises to identify the variable that is relevant to each concept as it is demonstrated.

Classroom Experiments on Gravity

Now that you have completed a pre-assessment of the students' understanding and used a few activities to introduce these areas to your class, you can further expand on this knowledge base by having the students conduct actual experiments that focus on gravity, motion, and force. Three, related experiments will be described below with complementary activities and suggestions listed in a Sidebar of this article for ways to expand these experiments to a larger group of related lesson plans for a week or two weeks. This series of lessons on gravity have been specifically designed to be flexible enough so that you can reproduce them to fit the individual needs and resources of your class. It is important to keep in mind however, that whether you use all or only some of this material, you should use constant repetition and hands-on practice whenever possible to reinforce key mathematical and scientific concepts.

Experiment A: Surface Area

To conduct this experiment, do these steps in sequence: a) Students will first be assigned by the instructor to a job for this experiment--a "Dropper", a "Timer", a "Recorder", and a "Facilitator; b) After receiving their jobs, the students will construct three square paper parachutes of various sizes (i.e., 4"x4", 8"x8", and 11"x11"); b)

Students will drop each parachute (i.e., 4"x4", 8"x8", and 11"x11") from six feet above a surface. They will drop each parachute three times; and c) The students will record the fall time for each trial on the appropriate worksheet, as illustrated in Figure 1. There will be nine trials recorded on the sheet, as there should be three trials for each different sized parachute.

Experiment B: Drop Time

To conduct this experiment, do these steps in sequence: a) Students will double the number of drops of each parachute, by dropping each chute (i.e., 4"x4", 8"x8", and 11"x11") three times from four feet; b) They will then repeat the process three times by dropping all chutes from a height of eight feet; and c) The students will record the fall time for each trial on the appropriate worksheet, as illustrated in Figure 2. The instructor can also assist the students to rotate the cooperative group task assignments between Steps a and b.

Experiment C: Weight

To conduct this experiment, do these steps in sequence: a) The students will again double the number of drops, but they will use a constant height of six feet for all experiments; b) They will drop the parachute with one washer attached to it a total of three times; c) The students will drop the parachute with two washers attached three additional times; d) As each drop occurs, the students in each group will again time the drop, measure each distance, and record their results on the Parachute Trials Worksheet found in Figure 3.

Unique Features and Applications of Sisters-In-Science Lessons

As you can see from the previous examples, both the complete lesson and its related, three experiments are excellent, practical ways to teach all students about the laws of gravity in elementary or middle school settings. We would encourage you to share these ideas with other regular and special education teachers in your building as examples showing how simple and cost-effective inclusionary science and math can be for all students. However, it is also important to keep in mind that this material was specifically created to meet the unique needs of three additional populations who often lose out when it comes to appropriate science, math, and technology; students with disabilities, female students, and students educated in inner-city schools. The previous lesson contains a wealth of valuable strategies and teaching materials for these groups as well. We have purposefully infused a number of critical components and strategies into the previous lesson plan that address the challenges often faced by girls, students with disabilities or students in inner-city classrooms.

First, we have proactively designed the science, math, and technology materials and curricula to meet the requirements of gender equity. For instance, the previous lesson relies heavily on a constructivist approach to teach both content and process skills. It has also been created to provide hands-on instruction about the concepts of surface area, distance, gravity, force, and motion in ways that is intrinsic to their collective learning style.

The lesson also contains the necessary background information on the topics and solicits a question throughout the lesson to promote inquiry on the part of the students. Another important aspect of the lesson is that it is based on the National Science Standards. Each activity is related to at least one content standard and at least one process standard.

In addition, to facilitate girls seeing themselves as successful adults in science, math, or technology we have used two other components for each teaching experience. We stress the importance of female, adult role models by using women both as instructors and group leaders throughout the lessons. We also make sure that each lesson has information to encourage the girls to read more about women who are currently leaders in the areas of science, math, technology, or engineering. For example in this lesson, the students read a case study on the Internet about female pilots and astronauts .

The second area that we have addressed throughout our work with Daughters with Disabilities is the area of disabilities. Because little currently exists in the field of special education to guide instruction in these areas, we have infused many, critical ideas into the previous lesson that we have found useful in the classroom to meet the often unique needs of students with a variety of special needs. For instance, we would suggest that before you use any of these materials, you must first look at these areas to provide appropriate accommodations for disabilities and on-going support for the best inclusionary practices in your classroom. You can do this in a number of ways, such as first analyzing the specific skills needed to successfully complete the lesson. Note whether they are cognitive, social, fine motor, gross motor, and so forth. You may find that the pre-assessment section of this lesson will be especially helpful to you here as you look at both the strengths and weaknesses of various students in your class.

Next, observe what type of compensation or current accommodations, if any, the student uses now in your class. Try to match this support, if possible, with what personnel or other resources you already have available to you. Also, check the Individual Educational Plan (IEP) to see what has been suggested by the parents and other building staff for this individual student. For instance in Figure 5, Susie's IEP says that she should have individuals at eye-level as she sits in her wheelchair during instruction and various classroom activities to increase her eye contact and foster attention to task. You may want to arrange where her group sits to make this more convenient for both Susie and her peers during this lesson.

Third, there are a number of other valuable ideas to keep in mind that clearly address the unique needs of students with special needs. During the lesson on gravity, it is very important to also try these hints: a) Incorporate social skills training and reinforcement whenever possible--Note that this lesson was specifically designed to use social skills, cooperative learning, and good communication within a group of no more than four peers for maximum instructional effectiveness and successful inclusion; b) Provide continual reinforcement of key SEM terms and ideas by all adults or peer tutors during this lesson (e.g., gravity, constancy, change, surface area, fall distance, force, motion, fall time, plot, graph, etc.) to both generalize the concepts and promote further understanding of these important science Benchmarks; c) Focus on inclusion versus exclusion of all students with special needs, whenever possible. For instance, you may do parts of the previous lesson in the special education classroom where the class is smaller, with more one-to-one attention. Then you can shift the rest of the lesson or the follow-up activities described in Sidebar 1 to the regular class setting where the students with disabilities are more fully incorporated with their non-disabled peers; d) Continue to stress, both in the school and at home, the on-going importance of self-determination skills for students with disabilities.

A simple example from this lesson as shown in Sidebar 3 is to give Susie the choice how she wants to complete her work by asking her, "Do you want to have the worksheet input ahead of time by your aide in your laptop? Would you rather have a peer act as a scribe for you?" Each choice supports Susie to build on her strengths, while compensating for her fine motor and written language problems in an inclusionary, instructional manner. Each choice also reinforces SEMT skills, knowledge acquisition, and self-determination as listed on her IEP.

Fourth, these materials and strategies have been specifically designed to meet the limitations of teaching science and math in inner-city (or other "resource-poor") educational settings. For instance, note that none of the activities require the use of complex, expensive equipment or must be taught in a science lab for maximum effectiveness. Another key component of all of the lessons from Sisters in Science and Daughters with Disabilities is that they use simple, home-made materials (i.e., paper towels, washers, paper clips, string, masking tape, pencils, etc.) that can be inexpensively purchased in most inner-city, rural, or suburban settings.

The emphasis on commonly used materials serves two very important purposes for the students during science and math lessons: a) it stresses familiar ideas and materials that the students see in their everyday environment to "de-mystify" basic scientific and mathematical concepts and b) it allows these same lessons to be generalized or easily duplicated at home whenever possible. Other advantages of these simple, but often powerful materials is that they are excellent vehicles for undergraduate training and in-service education of classroom teachers and paraprofessionals--both general and special education. These effective lessons, in turn, can also become an important component of inclusive education, as they can be used for team-teaching or follow-up in either special or regular, elementary classrooms with students both with and without disabilities. It should also be noted that we have found these lessons to have important applications to "pre-transition" training (i.e., future career goals, , skill development, and post-secondary educational awareness) for girls with disabilities who often rarely get the chance to participate in such activities or imagine themselves in pro-active roles as scientists, mathematicians, or researchers.

Conclusion

The previous material has shown that there definitely are many long-lasting benefits for both boys and girls with disabilities if they receive an appropriate education in science, math, and technology. But, we also discovered one more intriguing insight as part of our efforts with Daughters with Disabilities. We found to our surprise that there clearly were double winners in the process, because the teachers, as well as the students, were becoming excited and motivated to learn more about math, science and technology. As one of the Temple under-graduate students said after her work with us:

> Teaching science isn't as difficult and scary as I once thought. I grew up hating science. I was never good at it. . . [and] I was horrified about putting together a comprehensive science lesson plan. I was constantly worried that the students would ask me a question that I couldn't answer. I always thought that science was extremely dry and boring, [but]. . .this experience has changed my preconceptions of science 180 degrees. I learned that science is FUN! I also learned that there is a place for women and girls in the field of science.
>
> (Price & Hammrich, 2000)

Can science and math be fun and exciting for your students? Are the time and energy available in your classroom to encourage girls, as well as boys, to think of themselves as future scientists, accountants, astronauts, nurses, data analysts, or others who use math, science, and technology in their everyday jobs? Do you want to be a more effective teacher in these areas? If so, there is a whole world of resources and ideas just waiting for you and your students to discover. The suggestions and materials contained in this article are only the beginning. As one teacher told us, "This is a whole new world [that now] I can bring to my students.....This translates well into ALL of my teaching!"

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Figure 1. Suggestions for Inclusive Education for a Science Lesson* about Gravity--Parachute Trials Worksheet

Group Members: ______________________
____
____
____
____

Parachute Area	Trial #1	Trial #2	Trial #3
Average Time			

What is the variable?______________________

****Note: The actual worksheet will be scanned in at this point (Hammrich, 2000).**

Figure 2. Suggestions for Inclusive Education for a Science Lesson*
about Gravity--Labsheet for Experiment B

Group Members: ____________________

____

____

____

____

X Parachute Area ______ Average Time	(+ Height)	Trial #1	Trial #2	Trial #3

What is the variable?____________________

****Note: The actual worksheet will be scanned in at this point (Hammrich, 2000).**

Figure 3. Suggestions for Inclusive Education for a Science Lesson* about Gravity-- Labsheet for Experiment C

Group Members: ______________________
____
____
____
____

X Parachute Area ______ Average Time (+ Number of Washers)	Trial #1	Trial #2	Trial #3

What is the variable?______________________

****Note: The actual worksheet will be scanned in at this point (Hammrich, 2000).**

Sidebar 1: Follow-Up Lesson for Experiments A, B, and C

The following lesson can be used in its entirety or in specific sections, depending on the needs of your students, your classroom resources, time constraints, and group composition. This lesson is divided into two, related sections: A follow-up activity on developing line graphs to further organize the data from Experiments A, B, or C and a set of questions for the students to use as a catalyst to discuss and reflect on what they have learned and document in a personal Science Journal. **(Hammrich, 2000)**

I. Activity to Organize Your Data

Students will construct a line graph as part of this lesson. A line graph shows the relationships between two variables, such as time and distance. A graph of this type assists the students to visualize this relationship. Please note that each graph will have two components: labels on all axes with units (i.e., when x = the area of the parachute and y = the time that it takes for the parachute to fall); and a line that the students draw to connect each point on the graph.

The teacher will guide the students through the construction of a line graph on a single chart that may be enlarged, if needed onto a flipchart, or blackboard. The teacher will first help the student to create ordinal pairs for each parachute size, with explanations and examples of the term "ordinal pairs" if needed. Second, the students will plot each pair of data on the chart. Third, the students and the teacher will draw a line from pairs #1 to pairs #3. After this exercise, the teacher will further explain other components of the chart, such as: the slope of the lines, the direction of the lines or the data, and changes between ordinal pairs.

It is important for the teacher and the students to construct a separate graph for each of the parachute activities. While these activities are taking place, the teacher can ask the students such questions as, "What is the graph telling us about the parachutes? What is this graph (or are these graphs) telling us about the effects of gravity? How did you figure this out? What do you think caused the differences between the pairs of data?" **(Hammrich, 2000).**

II. Guided Discussion Questions:

To assist the students analyze, synthesize, and reflect on the new information that they are learning about gravity, constancy, and change, the teacher can use the following questions to focus the discussion or review key concepts for the students. For instance, these questions can be talked about orally with the whole class, used to elicit written responses on a short quiz, given as separate assignments for small group exploration, or typed into a computer for a student to solve on an individual basis(**Hammrich, 2000**).

Examples of questions that could be used are:

1. What things have caused the differences in time of the fall if the parachute was the same size?

2. If the size of the parachutes is the same, how do you think we could change the time it took for them to fall?

3. What patterns do you see in your data on this chart or how do these charts compare?

4. Why do you think the times have changed in the data on this chart or when you compare these charts?

5. What factors do you think have affected the motion of the parachutes when you compare these charts?

III. Writing a Science Journal (**Hammrich, 2000).**

Another valuable format to assist students with and without disabilities to analyze, synthesize, and reflect on the new information that they have discovered about gravity, constancy, and change is to keep a simple, scientific journal of their observations and ideas. This is an especially useful educational vehicle for students who may need additional practice with their writing skills, development of vocabulary, those students who have short-term memory loss, or need extra help to generalize this information. Some of these students may want to illustrate their journals with pictures, or charts. Others may want to write additional discussion questions or design new experiments about gravity, constancy, and change for their peers to conduct. These journals are excellent tools to share with parents and guardians as a way to integrate learning both in the home and school environments.

Examples of sample journal questions could be:

1. What is gravity?
2. How does gravity effect constancy and change?

You can also have the student write about, or try, this additional experiment:

1. If a watermelon and a lemon (or other objects) were dropped from the same height (such as the roof of your school or house), what do you think would happen?
2. How can you slow the lemon down or make the watermelon fall faster?
3. What does this tell you about the laws of gravity?
4. What does this tell you about the laws of constancy and change?
5. What other objects would fall at the same rate as the lemon? As the watermelon?
6. What objects would fall at different rates than the lemon? Than the watermelon? Why?

Sidebar 2: Examples of Individualized Educational Plan Goals and Objectives

To further personalized the science and math concepts described in this article for students with a wide variety of disabilities in your classroom, you can connect this information directly to various goals and/or objectives written in their Individualized Educational Plans (IEPs). The following examples can be used as stated or edited to fit the different strengths and weaknesses of your students.

I. Social Skills Goal: Cooperate in a group activity.

Sample Objective A: Given a Parachute Trials worksheet, the student will complete it with feedback from his/her group with 100% accuracy.

Sample Objective B: Given materials to complete Experiment A, the student will cooperate with three other group members to observe the fall three times of nine total trials of the parachute with 100% accuracy.

II. Communication Goal: Express oneself orally and in writing.

Sample Objective A: The student will be able to accurately describe orally the steps needed to create a parachute for one or more of the gravity experiments.

Sample Objective B: The student will be able to accurately write down the steps necessary to create a parachute for one or more of the gravity experiments.

III. Mathematical Goal: Measure mathematical relationships.

Sample Objective A: The student will be able to measure and compare the differences between different size and weight objects and their drop time mathematically.

Sample Objective B: The student will be able to measure and compare the differences between the size of the parachute and the weight of the object mathematically.

Sample Objective C: The student will be able to predict mathematically the drop time of an object when given its weight and the size of the parachute.

IV. Science Content Goal: Understand the specific scientific concepts of gravity, constancy, and change.

Sample Objective A: The student will be able to demonstrate how a variety of different objects react to gravity in relationship to their size, weight, shape, and density.

Sample Objective B: The student will be able to demonstrate how gravity, constancy, and change remain the same, though variables are different.

V. Science Skill Goal: Practice skills integral to the scientific method.

Sample Objective A: The student will be able to explain verbally and demonstrate the concept of variables.

Sample Objective B: The student will be able to explain verbally and demonstrate the scientific method of comparing and contrasting different size objects and how they respond to gravity.

Sample Objective C: The student will be able to explain verbally and demonstrate the scientific method of comparing and contrasting different weight objects and how they respond to gravity.

Sample Objective D: The student will be able to explain verbally and demonstrate the scientific method of comparing and contrasting different shaped objects and how they respond to gravity.

Sample Objective E: The student will be able to classify and categorize experimental results by size of object, type and shape of object, and the size of the parachute.

VI. Technology Goal: The student will be able to find websites that provide additional information on scientific concepts learned in this experiment such as the effects of gravity on a variety of objects and in a variety of situations.

Sample Objective A: The student will be able to independently find 5 source websites on the Internet that provide additional information on gravity.

Sample Objective B: The student will be able to independently find 2 source sites that find practical uses of gravity in modern day construction of large buildings and or bridges.

Sample Objective C: The student will be able to independently find 2 source websites that provide information on the history and discovery of gravitational pull.

Sample Objective E: The student will be able to independently find information on the effects of gravitational pull in space travel and report on it in writing.

Sidebar 3: Suggestions for Inclusive Education for a Science Lesson about Gravity, Constancy, and Change*

Specific Activity	Suggested Accommodations for Susie
1) Fill out various worksheets	Do the activity with a peer or group member Use a laptop computer to fill out sheets Group member acts as a scribe to fill out worksheet
2) Manipulate objects and tools (washers, ruler, paper clips, etc.)	Partner manipulates objects and tools to compensate for fine motor problems Susie can also tell her partner what to do
3) Verbal discussion and oral problem-solving	Peer sits at eye-level (since Susie uses a wheelchair) Peers encourage Susie to speak slowly Give this whole group extra time, if needed
4) Measure the fall distance of each parachute	See number 2 above. . This also applies to dropping each parachute in Experiments A, B, and C.
5) Hypothesize about each object's rate of speed	No accommodation needed
6) Graph the area and fall time of each object	See numbers 1 and 2 above

(Sidebar 3 cont.)

*Please Note: These accommodations were designed for a hypothetical student, we have named "Susie". She is being taught in an inclusive, fifth grade classroom in a large, urban school district. Due to her cerebral palsy, Susie has limited fine and gross motor control, along with poor speech articulation. She uses a power wheelchair and uses an adapted lap-top computer for written communication. She is encouraged to use her oral language whenever possible. Susie also has various strengths, such as: excellent social skills, above average intelligence, age-appropriate math and science skills, many hobbies, and a high level of motivation. Susie is a Startrek fan and constantly reads science fiction. She has expressed an interest to be an astronaut or work someday in the areospace industry.

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